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MULTIFUNCTIONAL RESIDENTIAL COMPLEXES IN THE URBAN STRUCTURE OF KARLSRUHE**I. Yanishevskyi**

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Annotation. In the context of contemporary urbanization processes, climate change, and the growing demand for high-quality and affordable housing, European cities are facing the need to transition toward sustainable and integrated models of spatial development. One of the key forms of such transformation is multifunctional residential complexes that combine housing, public spaces, service facilities, and elements of green infrastructure. The aim of this study is to conduct a comprehensive analysis of the architectural and urban planning foundations underlying the formation of contemporary residential complexes and multifunctional residential ensembles in the city of Karlsruhe as key elements of a sustainable urban environment, as well as to determine their role in the transformation of the spatial structure, functional organization, and quality of the residential environment within the framework of compact and integrated urban development.

The study applies a comprehensive architectural and urban-planning approach, including an analysis of the urban structure of Karlsruhe, a typological study of residential and multifunctional complexes, and an examination of key projects—**BadenCarré**, **Rintheimer Feld**, and **Ettlinger Tor**. Particular attention is paid to issues of multifunctionality, the organization of public spaces, the integration of social infrastructure, and the application of sustainable development principles.

As a result of the study, it has been established that contemporary residential complexes in Karlsruhe form a qualitatively new type of organization of urban residential development based on high density, multifunctionality, and orientation toward public transport. Such complexes contribute to reducing transport dependency, improving the quality of the residential environment, and enhancing the resilience of the urban structure. The findings confirm that the experience of Karlsruhe can be regarded as a promising model for the transformation of residential development in European and post-socialist cities.

Keywords: Karlsruhe; residential complexes; multifunctional development; sustainable development; urban structure; block development.

Relevance of the Study. Under conditions of contemporary socio-economic, environmental, and demographic change, European cities face a complex set of interrelated challenges, among which ensuring access to high-quality and affordable housing while maintaining the resilience of the urban environment occupies a central position [1]. Urbanisation processes, growth of the urban population, changes in household structures, and increasing migration flows lead to higher housing demand, especially in economically developed and innovation-driven European cities. In parallel, requirements for the environmental performance and energy efficiency of buildings, as well as for the rational use of land resources, are becoming more stringent [2].

In this context, traditional mono-functional residential development models typical of the second half of the twentieth century are gradually losing their effectiveness. They often generate excessive dependence on private cars, spatial fragmentation of the urban fabric, and degradation of public spaces [3]. Contemporary urban planning practice is increasingly oriented toward compact,

multifunctional, and socially integrated residential neighbourhoods, where housing is combined with workplaces, services, educational facilities, recreation, and green infrastructure. Such complexes are considered a basis for sustainable urban development and an instrument for improving quality of life while minimising adverse environmental impacts [1].

These approaches are particularly relevant in German cities, where a consistent policy of inner-city densification and limiting expansion into suburban areas is being implemented. German cities serve as testing grounds for contemporary sustainable urban development models that integrate multifunctionality, public transport orientation, and climate adaptation principles [4]. In this regard, Karlsruhe is an illustrative case in which modern residential and multifunctional complexes act as tools for transforming the urban structure, forming new integrated neighbourhoods, and redeveloping former industrial and infrastructural areas.

The relevance of the study is also determined by the fact that, in academic literature and planning practice, the principles of shaping such complexes in the context of specific cities are still insufficiently systematised. This is particularly important for adapting and transferring successful models to other European and post-socialist cities undergoing transformations of their housing stock and spatial structure. The study of residential and multifunctional complexes in Karlsruhe is relevant from both theoretical and practical perspectives, as it enables a deeper understanding of contemporary trends in sustainable urban development and supports the development of scientifically grounded approaches to the evolution of the urban residential environment in the twenty-first century [1, 4].

General Problem Statement. Contemporary European urban development is characterised by a shift from extensive territorial growth models to compact and sustainable development strategies based on functional integration, increased density, and the provision of a high-quality urban environment [5]. In this context, new-generation residential and multifunctional complexes are becoming key elements of the city's spatial organisation, shaping everyday life, mobility patterns, and residents' social interaction [6].

At the same time, in both academic research and planning practice, such objects are often considered in a fragmented way—either from the perspective of architectural solutions for individual buildings or as components of investment and development projects—without a comprehensive analysis of their role in forming a resilient urban structure [7]. This approach does not allow for a full assessment of the spatial, social, and environmental consequences of introducing multifunctional development.

The problem is that the lack of a systemic architectural and urban-planning approach to the study of residential and multifunctional complexes complicates the understanding of their real impact on urban development. Under conditions of intensified construction, redevelopment of industrial and infrastructural areas, and growing social and functional complexity of neighbourhoods, such complexes should be treated as integral elements of urban morphology rather than as isolated construction objects [5]. This is especially relevant for German cities, where principles of inner-city densification, sustainable mobility, and functional mix are embedded in the urban planning regulatory framework, yet implemented through a wide variety of design solutions.

Karlsruhe is a representative example of a city where processes of urban structural transformation are closely linked to the development of residential and multifunctional complexes. As a result of redeveloping former industrial, railway, and military areas, new residential neighbourhoods are being formed that combine housing, workplaces, public spaces, and everyday infrastructure. However, despite the evident significance of these projects, a comprehensive scientific framework capable of evaluating how different development typologies, spatial solutions,

and functional combinations affect urban resilience, social cohesion, and environmental performance is still lacking [6, 7].

Thus, the scientific problem lies in the need to develop an integrated analytical approach to studying residential and multifunctional complexes in Karlsruhe as structure-forming elements of a sustainable city. Without such an approach, it is impossible to objectively assess their potential in addressing key tasks of contemporary urban development—ensuring affordable housing, reducing transport dependency, creating high-quality public spaces, and adapting the urban environment to climate change. This problem defines the relevance and the direction of the present study [5].

Review of Recent Research and Publications. In 2020–2025, scholarly discussion on residential and multifunctional complexes increasingly shifted from the analysis of individual objects to the study of the neighbourhood as a resilient urban system. In contemporary European research, such neighbourhoods are viewed not only as combinations of housing and retail, but as complex hybrid structures that integrate local economies, social functions, and everyday mobility. This is reflected, in particular, in the systematic review by Puggioni and Tontisirin (2025), *“Mixed-use Developments and Urban Megaprojects in the Global South...”*, where the authors emphasise that mixed-use is conceptualised as a broader model encompassing diverse urban functions and sustainable space-use scenarios [8].

Analyses of the influence of the built environment on mixed land use show that combining dense residential development with other functions correlates positively with indicators of accessibility and social sustainability at the neighbourhood scale. In the study by Li et al. (2024), *“The Impact of Built Environment on Mixed Land Use: Evidence from Xi’an”*, it is established that physical parameters of development (density, street hierarchy, and the structure of public spaces) are directly associated with the effectiveness of mixed-use models and their perceived sustainability by users [9]. Although this example is outside the German context, the methodology and findings are relevant for European—and specifically German—research focused on assessing environmental quality in multifunctional neighbourhoods.

Furthermore, issues of sustainable redevelopment and brownfield transformation have become increasingly important in urban research, especially in the context of “zero land take” goals and enhanced environmental efficiency. In the work by Zheng and Masrabaye (2023), *“Sustainable Brownfield Redevelopment and Planning: Bibliometric and Visual Analysis”*, a bibliometric analysis of brownfield-related publications demonstrates a growing scholarly interest in integrated planning models, environmental effects, and the social consequences of redevelopment [10]. The authors note that in recent years, studies of mixed-use neighbourhoods increasingly include assessments of how the reuse of former industrial and infrastructural sites affects the resilience of the urban fabric.

Overall, the literature review for 2020–2025 indicates a clear shift in research focus from the individual object to integrated neighbourhood systems, within which residential, public, and economic functions are analysed within a unified sustainability framework. This is particularly important for Germany and Europe more broadly, where mixed use, territorial regeneration, and urban resilience have become central issues, and where redevelopment experience can provide a methodological basis for further analysis of residential and multifunctional complexes, including those in Karlsruhe.

Aim of the Study. The aim of this study is to carry out a comprehensive analysis of the architectural and urban planning frameworks underlying the formation of contemporary residential complexes and multifunctional residential ensembles in the city of Karlsruhe as key components of a sustainable urban environment, as well as to determine their role in the transformation of the

spatial structure, functional organization, and quality of the residential environment within the context of compact and integrated urban development.

Within this aim, residential complexes are considered not only as housing construction objects, but as urban formations that shape neighbourhoods, public spaces, local infrastructure, and everyday life scenarios. This approach makes it possible to assess their impact on urban resilience, social integration, and environmental efficiency in Karlsruhe.

Research Objectives. To achieve the stated aim, the study addresses the following interrelated objectives:

- to analyse architectural and urban typologies of residential and multifunctional complexes in contemporary development in Karlsruhe and identify their morphological and spatial characteristics;
- to examine the functional structure of these complexes, including the balance of residential, public, commercial, and recreational functions, as well as the character of their spatial organisation;
- to identify key principles of residential development in Karlsruhe in the context of sustainable urban planning, including development density, public transport orientation, the use of green infrastructure, and energy-efficient solutions;
- to assess the degree of integration of residential and multifunctional complexes into the existing urban fabric of Karlsruhe, including their relationship with the street network, public spaces, and transport infrastructure;
- to determine the impact of the analysed residential complexes on urban environmental quality, social integration, and the formation of resilient urban neighbourhoods.

Main Body. Karlsruhe is distinguished by a unique urban structure formed on the basis of a radial–fan composition, within which the historic centre with the palace and the central square functions as a spatial core from which the main streets and transport axes radiate. This structure ensures a high degree of spatial legibility and contributes to a balanced distribution of urban functions [11]. At the present stage of Karlsruhe’s development, this structure is being complemented by processes of densification and reorganisation of peripheral and semi-peripheral areas, primarily former industrial, railway, and military zones.

A well-developed public transport system—above all the tram–train network (the Karlsruhe Model)—forms a resilient urban framework and provides high accessibility to new residential areas. New residential and multifunctional complexes are concentrated along these transport corridors and near transfer nodes, in line with the principles of transit-oriented development (TOD). As a result, a polycentric urban structure is emerging, in which contemporary residential neighbourhoods assume the role of new local centres of urban activity [11].

Several stable architectural and urban typologies of residential and multifunctional complexes can be identified in Karlsruhe’s contemporary development. The most widespread is perimeter block development with internal courtyards, which clearly delineates public and semi-private spaces and creates favourable conditions for everyday social interaction. This typology is widely applied in the redevelopment of industrial areas and results in dense yet comfortable urban blocks. Alongside this, linear and comb-shaped residential buildings oriented along arterial roads and transport corridors are used, as well as compact ensembles organised around internal pedestrian spaces. A special place is occupied by hybrid buildings that combine housing with office, retail, and public functions. Such projects create vertically and horizontally integrated urban environments, reflecting current trends toward functional mixing and flexible use of space [11].

The BadenCarré residential complex represents a demonstrative example of contemporary high-density block development in the central part of Karlsruhe, implemented within the framework of sustainable development and inner-city densification strategies (Innenentwicklung). The project is based on the traditional German block morphology, with a clearly defined perimeter and a system of semi-public internal courtyards that ensures a balance between private and public spaces. The architectural and planning structure of the complex is oriented toward the creation of a high-quality residential environment through a multi-level system of open spaces, including landscaped courtyards, pedestrian passages, local public areas, and active ground floors. The internal courtyards perform not only recreational functions but also act as elements of microclimatic regulation, reducing heat loads and improving the environmental performance of the development.

The volumetric and spatial composition of the complex is characterised by variability in building heights and façade rhythms, which helps to avoid the monotony of dense development and contributes to the visual articulation of the block. The use of contemporary materials combined with a neutral colour palette ensures the architectural integration of the complex into the historically established urban fabric without disrupting the scale or character of the surrounding development. The functional structure of BadenCarré is based on a diversity of housing typologies—from compact units for students and young professionals to family-oriented and adaptable dwellings—thus supporting social differentiation and the resilience of the local community. The inclusion of everyday services, office spaces, and public functions alongside housing strengthens functional mix and generates an active urban environment throughout the day [11].

Accordingly, the BadenCarré residential complex can be regarded as a successful model of a contemporary multifunctional residential development, in which architectural and urban planning solutions are aimed at improving urban environmental quality, fostering social integration, and supporting the sustainable development of central city areas.

The Rintheimer Feld project reflects a consistent approach to the formation of a residential neighbourhood as an integrated urban unit, in which architectural, functional, and transport-planning decisions are considered in close interrelation [12]. The neighbourhood is designed on the principles of functional integration and local self-sufficiency, allowing it to be interpreted as an example of sustainable residential development within the urban structure of Karlsruhe. Residential buildings in Rintheimer Feld are organically combined with everyday infrastructure—retail premises, childcare facilities, educational and social institutions—as well as a system of public and semi-public spaces, corresponding to contemporary German approaches to neighbourhood development [13].

Such functional composition ensures a high level of accessibility to essential services within walking distance and creates an active urban environment at the neighbourhood scale. The spatial organisation of the area prioritises pedestrian and bicycle movement. The street network has a hierarchical structure that restricts through-traffic within residential zones, thereby reducing noise and environmental impacts and aligning with the principles of sustainable urban mobility [14]. Internal neighbourhood spaces are designed as safe and comfortable environments for everyday activities, social interaction, and residents' recreation.

The architectural and planning solutions of Rintheimer Feld demonstrate an emphasis on human-scale development, diversity of housing typologies, and the creation of a clearly legible spatial structure. Taken together, these characteristics allow the project to be regarded as a resilient model of a residential neighbourhood oriented toward reducing dependence on private cars and improving overall urban environmental quality [12].

The Ettlinger Tor complex functions as a central multifunctional hub combining residential, retail, office, and public uses. Its significance extends beyond that of a single project, as it contributes to the transformation of central Karlsruhe by reinforcing its role as a business and social

centre and demonstrating the potential for integrating large-scale mixed-use developments into the existing urban fabric [15].

One of the key characteristics of contemporary residential complexes in Karlsruhe is a high degree of functional mixing. Residential uses are complemented by retail, services, educational facilities, and workspaces, which supports the formation of resilient local communities and reduces the need for long daily commutes. This corresponds to the concept of the “city of short distances,” within which residents’ primary needs are met within walking distance [13].

Social infrastructure—schools, kindergartens, healthcare and cultural institutions—is integrated directly into the structure of residential neighbourhoods, enhancing their autonomy and social resilience. Such solutions create the preconditions for the formation of strong local identities and an overall improvement in urban quality of life [14].

The environmental resilience of Karlsruhe’s residential complexes is ensured through a combination of energy-efficient building standards, well-developed green infrastructure, and the rational use of land resources. Internal courtyards, green roofs, and stormwater management systems contribute to improved microclimatic conditions and support the adaptation of the urban environment to climate change [15].

From a spatial perspective, resilience is achieved through high development density, compact neighbourhood layouts, and orientation toward public transport, which reduces reliance on private vehicles, lowers emissions, and enhances the overall quality of the urban environment.

Conclusions. The conducted study has demonstrated that contemporary residential and multifunctional complexes in Karlsruhe function not merely as housing developments, but as key structure-forming elements of a resilient urban environment. Their development follows the logic of compact and integrated urban growth, oriented toward the principles of inner-city densification, functional mix, and sustainable mobility, in line with current urban planning strategies of Germany and the European Union.

An analysis of Karlsruhe’s urban structure revealed that the location of new residential complexes is closely linked to the city’s transport framework and to the redevelopment zones of former industrial and infrastructural areas. This makes it possible to effectively integrate previously underused sites into the urban fabric and to create new residential neighbourhoods without expanding the city’s boundaries. Thus, residential complexes serve not only as a means of quantitatively increasing the housing stock, but also as instruments of qualitative transformation of the urban structure.

The typological analysis confirmed the predominance of block-based and hybrid development, oriented toward the formation of systems of internal courtyards, pedestrian spaces, and local public areas. Such spatial solutions contribute to improving the quality of the residential environment, fostering socially resilient communities, and clearly delineating public, semi-public, and private spaces. Multifunctional elements integrated into the structure of residential complexes ensure everyday accessibility of services and strengthen the local identity of neighbourhoods.

The analysis of key case studies—BadenCarré, Rintheimer Feld, and Ettlinger Tor—confirmed that contemporary projects in Karlsruhe demonstrate a high level of architectural and urban integration as well as functional diversity. These complexes contribute to the formation of new centres of urban activity, reduce residents’ dependence on private transport, and enhance the social and economic resilience of the urban environment.

The environmental analysis showed that the resilience of residential complexes is ensured through a combination of high development density, orientation toward public transport, the implementation of energy-efficient technologies, and the development of green infrastructure. This

approach reduces environmental pressures, improves microclimatic conditions, and supports the adaptation of the urban environment to climate change.

Overall, the experience of Karlsruhe demonstrates that contemporary residential and multifunctional complexes can be regarded as effective instruments of sustainable urban transformation, combining economic feasibility, social integration, and environmental responsibility. The obtained results may be applied in the development of strategies for housing renewal and territorial redevelopment in cities of Europe and post-socialist countries.

Prospects for Further Research. Future research in the field of architectural and urban planning formation of residential and multifunctional complexes is associated with the need for a deeper and more multidimensional analysis of urban transformation processes under conditions of sustainable development. First and foremost, it appears advisable to expand comparative studies aimed at juxtaposing the experience of Karlsruhe with practices in other cities of Germany and the European Union. This would make it possible to identify both universal patterns in the formation of resilient residential neighbourhoods and specific features shaped by local socio-economic and spatial conditions.

An important direction for further research is the analysis of the social dimension of residential complex functioning, including processes of local community formation, spatial patterns of everyday behaviour, and the impact of architectural and urban planning solutions on levels of social integration and quality of life. Particular attention should be paid to issues of housing affordability, diversity of household types, and mechanisms of social mix within new residential neighbourhoods.

Further in-depth environmental research is also promising, particularly studies related to life-cycle assessment of buildings, energy efficiency, carbon footprints, and the adaptation of residential complexes to climate change. The use of digital tools—GIS, BIM, spatial modelling, and big data analysis—can significantly enhance the accuracy and robustness of such assessments.

Additional attention should be given to the redevelopment of industrial and infrastructural areas, within which residential and multifunctional complexes act as catalysts of spatial and economic transformation. Research into governance mechanisms for such projects, interactions between public and private stakeholders, and tools for resident participation could substantially broaden the understanding of sustainable urban development models.

Finally, the findings based on the Karlsruhe case are of considerable interest for adaptation in post-socialist cities, including cities in Ukraine, where the renewal of housing stock and the revitalisation of urban areas are particularly pressing issues. This opens up opportunities for further interdisciplinary and international research in the field of sustainable urban planning.

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БАГАТОФУНКЦІОНАЛЬНІ ЖИТЛОВІ КОМПЛЕКСИ У МІСТОБУДІВНІЙ СТРУКТУРІ КАРЛСРУЕ

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Анотація. В умовах сучасних процесів урбанізації, кліматичних змін і зростання потреби в якісному та доступному житлі європейські міста стикаються з необхідністю переходу до сталих та інтегрованих моделей просторового розвитку. Однією з ключових форм такої трансформації стають житлові багатофункціональні комплекси, що поєднують житло, громадські простори, об'єкти обслуговування та елементи зеленої інфраструктури. Метою статті є виявлення та наукове обґрунтування архітектурно-містобудівних принципів формування житлових багатофункціональних комплексів міста Карлсруе як структуроутворюючих елементів сталої міської середовища, а також визначення їх впливу на трансформацію просторової, функціональної, соціальної та екологічної організації міста.

У статті застосовано комплексний архітектурно-містобудівний підхід, що включає аналіз міської структури Карлсруе, типологічне дослідження житлових і багатофункціональних комплексів, а також розгляд ключових проєктів — *BadenCarré*, *Rintheimer Feld* та *Ettlinger Tor*. Особливу увагу приділено питанням багатофункціональності, організації громадських просторів, інтеграції соціальної інфраструктури та застосуванню принципів сталого розвитку.

У результаті дослідження встановлено, що сучасні житлові комплекси Карлсруе формують нову модель міського кварталу, засновану на високій щільності, багатофункціональності та орієнтації на громадський транспорт. Такі комплекси сприяють зменшенню транспортної залежності, підвищенню якості житлового середовища та стійкості міської структури. Отримані висновки підтверджують, що досвід Карлсруе може розглядатися як перспективна модель трансформації житлової забудови в європейських і постсоціалістичних містах.

Ключові слова: Карлсруе, житлові комплекси, багатофункціональна забудова, сталий розвиток, міська структура, квартальна забудова.

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